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This paper focuses on efficiency measures of banks from six countries in Southeast and East Asia. We use a two-stage approach to study the post-crisis period 1999-2004. We first estimate technical efficiencies using Data Envelopment Analysis and test for cross-country differences. Efficiency scores are relatively high for South Korea and relatively low for the Philippines. We then investigate the link between ownership structure and efficiency controlling for various factors such as size, risk and the economic environment. We find that efficiency scores are higher for banks which are held by minority private shareholders and banks that are foreign-owned.

Keywords: bank efficiency, ownership structure, DEA, Southeast Asia, East Asia

1 Introduction

The financial crisis that hit Southeast Asia in 1997 raised various issues regarding the efficiency and the safety of local banking industries. After the crisis, bank regulators implemented several measures to reform the banking system with the aim of providing efficient banking services to the economy on a sustainable basis (Garcia, 1997). First, some governments decided to avoid closure of distressed banks by recapitalizing them. This process was accompanied by changes in management, ownership and governance. Second, Asian governments also avoided closure of banks by encouraging or even forcing safe banks to merge with distressed banks (Hawkins & Turner, 1999; Hawkins & Mihaljek, 2001; Gelos & Roldós, 2004). This consolidation process contributed to the restoration of the financial viability of distressed banks even if it is not clear whether merging a weak bank with a strong bank can actually create a strong intermediary (Hawkins & Turner, 1999). However, such interventions could still be more cost-effective than a government bailout or takeover. Third, Asian governments have facilitated access of foreign investors in order to import international best practices and technological benefits (Choi & Clovutivat, 2004). Finally, many other restructuring processes were also implemented such as the replacement of underperforming bank managers and revision of managerial incentives.

This bank restructuring program, which began almost immediately after the crisis in 1997 and which lasted until the early 2000s, modified the ownership structure and the governance of banks. This paper investigates the implications of such policies on the efficiency of commercial banks in Southeast and East Asia during the post-crisis period 1999-2004. The countries examined in this paper are: Hong Kong (China) and South Korea in East Asia, and Indonesia, Malaysia, the Philippines and Thailand in Southeast Asia. Except for Hong Kong, all these financial systems have long been dominated by commercial banks with extensive branch network which have been the most affected by the Asian financial crisis in 1997 (Laeven, 1999). Drake, Hall, and Simper (2006) however note that banks in Hong Kong also sharply suffered during the Asian financial crisis in 1997-1998 as it coincided with a local property market crash resulting in depressed profits and increased bad debts. Hence, the common experience of the six countries is a unique feature to assess the implications of the restructuring process that took place after the crisis.

Previous studies on emerging countries which have analyzed the impact of restructuring programs on bank efficiency do not provide conclusive results. Papers which have studied the relationship between foreign bank entry and efficiency in transition countries find mixed results (Claessens, Demirgüç-Kunt, & Huizinga, 2001; Fries & Taci, 2002; Bonin, Hasan & Wachtel, 2005). Unite and Sullivan (2003) show that foreign entry in the banking market in the Philippines corresponds to an improvement in operating efficiencies, but with deterioration in the quality of loan

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portfolios. The studies which examine the link between bank ownership and efficiency, especially in transition economies, also provide mixed results (Grigorian & Manole, 2002; Yildrim & Philippatos, 2002; Fries & Taci, 2005; Bonin, Hasan & Wachtel, 2005). For Asian countries, Laeven (1999) examines the risk factors and efficiency of banks using Data Envelopment Analysis, applied to the pre-crisis 1992-1996 period to predict which banks were restructured after the crisis of 1997. His findings show that state-owned and foreign-owned banks as well as Korean and Malaysian banks took little risk relative to other banks, while family-owned and company-owned banks and Indonesian and Philippine banks were among the highest risk-takers. Williams and Nguyen (2005) focus on the link between bank performance and governance for five East Asian countries (Indonesia, South Korea, Malaysia, Philippines, and Thailand) between 1990 and 2003. Their findings show that, as a result of bank privatization programs, banks selected for domestic mergers and acquisitions (M&As) exhibited relatively low rank order profit efficiency before the governance change, which improved in the short-term but deteriorated in the long-term implying a temporary efficiency gain. Their results suggest that the benefits of domestic M&As are realized in terms of technical developments, which determine productivity rather than managerial performance. They also find a considerable improvement in rank order technical change and productivity in the short-term after M&As, which was maintained in the long-term. On the whole, their conclusions tend to support bank privatization and reject state ownership although their findings suggest that the potential benefits of foreign ownership may take a long time to be realized.

This paper extends the existing literature in three directions. First, the paper tests whether banks perform differently across countries during the post crisis period to focus on the implications of the restructuring process in the region. Our data therefore cover the 1999-2004 period. Second, we use a more detailed breakdown of bank ownership than in previous studies (i.e., state-owned, foreign-owned, private-owned, institutional investor-owned and widely-held). Third, two efficiency measure –technical efficiency and efficiency of revenue creation– are investigated in relation to bank characteristics such as ownership structure measures, size, risk indicators and environmental variables. Hence, we focus on efficiency measures consistent with institutions mainly involved in traditional intermediation activities (loans and deposits) as well as on measures which capture more accurately expanded bank activities such as the provision of services (commission- and fee-based) and trading activities.

The rest of the paper is structured as follows: Section two presents the methodology used to compute efficiency scores, as well as our dataset and the obtained results, Section three investigates the determinants of efficiency scores, and Section four concludes.

2 Efficiency Estimates

2.1 Method

In this study, we use the Data Envelopment Analysis (DEA) with variable returns to scale (VRS) to compute efficiency scores. The choice of VRS over constant return to scale (CRS) is justified on the grounds that not all decision-making units (DMUs) are operating at an optimal scale due to imperfect competition and financial constraints. As we assume variable returns to scale, we can use two approaches to measure efficiency: the input-oriented (input minimization) approach and the output-oriented (revenue model) approach[1]. These two models will estimate exactly the same frontier and then by definition will identify the same set of efficient DMUs but these two models will differ on the efficiency measures associated with the inefficient DMUs.

We use the intermediation approach in both input-oriented and output-oriented models. The intermediation approach, originally proposed by Sealey and Lindley (1977), is appropriate when banks operate as independent entities[2] (Bos & Kool, 2006). Moreover, the intermediation approach which takes interest expenses into account may be more appropriate to evaluate financial institutions as they represent in general at least half of total costs (Berger & Humphrey, 1997).

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[1] The input-oriented model and the output oriented-model provide the same value of efficiency scores under CRS but not when VRS is assumed.

[2] On the contrary, studies which consider bank branch efficiencies use the production approach.

In the input-oriented model (Model 1), we assume that the main role of banks is to transfer funds between depositors and borrowers at the lowest costs. We therefore consider personnel expenses, interest expenses and other operating expenses as inputs, and net loans, total securities and other earning assets as outputs. We follow Hughes, Mester and Moon (2000) and assume that interest is an input (expense), which is consistent with the input minimization objective of Model 1. Total securities include equity investments by the banks while other earning assets include physical property and premises that are used in revenue generation like safekeeping transactions. The specification of Model 1 is as follows:

Model 1: DEA VRS Input-Oriented

$$\min \theta$$

Such that:

$$\sum_{j=1}^{n} \lambda_j X_{ij} \leq \theta X_{i0} \; ; \; i = 1,2,\dots,m$$
$$\sum_{j=1}^{n} \lambda_j Y_{rj} \leq Y_{r0} \; ; \; r = 1,2,\dots,s$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda_j \geq 0 \; ; j \in 1,2,\dots,n$$

where θ is the efficiency score, x_{ij} and y_{ij} are the amount of the i^{th} input consumed and the amount of the r^{th} output generated by the j^{th} bank, respectively. The index n refers to number of bank observations, m equals the three inputs (personnel expenses, interest expenses and other operating expenses) and s refers to the three outputs (net loans, total securities and other earning assets).

As non-traditional bank activities, such as commission- and fee-based activities and trading activities have become more important, the exclusion of these items may bias efficiency measures (Berger & Mester, 1997). We use Model 2, which is an output maximization problem, to account for bank activity diversification. We follow Sturm and Williams (2004; 2006) and Avkirian (1999; 2000) by considering the interest expenses and the non-interest expenses as inputs and the net interest income and the non-interest income as outputs. Model 2 is specified as follows:

Model 2: DEA VRS Output Oriented-Revenue Creation

$$\max(1-\phi)$$

Such that:

$$\sum_{j=1}^{n} \lambda_j y_{rj} \leq (1-\phi) y_{r0}$$
$$\textstyle\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} \; ; \; r = 1,2,\dots,s$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda_j \geq 0$$

where $(1-\phi)^{-1}$ is the efficiency score, x_{ij} and y_{ij} are the amount of the i^{th} input consumed and the amount of the r^{th} output generated by the j^{th} bank, respectively. The index n refers to the number of bank observations, m equals the two inputs (interest expenses and non-interest expenses) and s refers to the two outputs (net interest income and non-interest income).

2.2 Data

The dataset used in this study contains observations from 1999 to 2004 on the population of banks in Hong Kong, Indonesia, South Korea, Malaysia, the Philippines and Thailand available in the Bankscope database, which reports published financial statements from financial institutions worldwide. To maintain consistency across countries, only commercial banks are included in the analysis, which gives us 238 banks. We delete banks with less than five years of time series observations[3]. The final sample consists of 80 Asian banks among which 38 are listed on a stock exchange (17 banks in Hong Kong, 12 banks in Indonesia, 13 banks in South Korea, 20 banks in Malaysia, 12 banks in the Philippines, and 6 banks in Thailand) yielding 358 bank-year observations (see Table A1 in the Appendix for details on the distribution of the sample). The sample consists of 72 large banks (total assets above one billion US dollars). In as much as we want a panel data approach to track possible technical changes or shifts in the frontier utilizing DEA, attrition reduces the number of cross-sections and to include only surviving banks might lead to survivor bias. The period 1999 to 2004 is chosen because the effect of the exogenous shocks to the region (Asian financial crisis) has passed and will no longer distort the estimates. If too short a period is chosen, inefficiency might not average out. If too long a period is chosen, the bank's efficiency score becomes less meaningful because of possible changes in management and other events. Berger & Mester (1997) concur with De Young (1997) that a six-year period reasonably balances the concerns of having too short or too long a period. The information for the country environmental level variables is sourced from the Asian Development Bank.

Table A2 provides some descriptive statistics of our dataset. Deposits are the main resource of the banks in our sample (75.62%) and loans are their main assets (53.12%). On average, interest income and non-interest income represent respectively around 69% and 29% of their total income. Therefore, the banks in our sample include both traditional and non-traditional banking activities. The total capital ratio is equal to 16.53% on average showing that, on the whole, banks are well capitalized and have build up capital buffers over the period 1999 to 2004. The level of non-performing loans differs significantly between countries. The ratio of non-performing loans to gross loans remains relatively high after the crisis period for the Philippines, Malaysia and Thailand. Conversely, this same ratio is relatively low for Hong Kong, South Korea and Indonesia.

In our study, we code the ownership structure based on the stockholder information contained in the BankScope database. For banks with missing information, we have looked at the individual bank's websites to determine the appropriate classification. Majority ownership is defined as owning over 33% of the stockholders' equity, following Laeven (1999). We consider a more detailed breakdown of bank ownership than in previous studies. We examine similar ownership forms as in Laeven (1999) but we also take institutional investors into account and hence consider five categories of ownership defined as[4]: (i) state-owned, shares being held by government institutions and corporations (9 banks); (ii) foreign-owned, shares being held by parent bank in foreign country or the bank being a foreign subsidiary (17 banks); (iii) private, shares being held by private companies as well as family-owned (35 banks); (iv) institutional investor-owned, shares being held by insurance companies and pension funds (11 banks); and, (v) widely-held, shares held by individual shareholders with stakes ranging from 5 to 33 percent (8 banks).

2.3 Results

Model 1 (Equation 1) and Model 2 (Equation 2) are used to calculate pure technical efficiency, denoted respectively PTE1 and PTE2[5]. The pure technical efficiency scores we obtain are displayed in Table 1, as well as the technical efficiency scores (TE1 and TE2) and the scale technical efficiency scores (SE1 and SE2)[6].

[3] This condition enables us to accurately compute the standard deviations of some variables. For Indonesia we use four years of time series observations.

[4] Among the 80 banks in our sample, none was classified under two categories of ownership simultaneously. Otherwise, we would have deleted such banks from our sample.

[5] We use the DEAP Version 2.1 Computer Program by Tim Coelli to solve the linear programming problem.

[6] SE1 is equal to the ratio of TE1 to PTE1 and SE2 is equal to the ratio of TE2 to PTE2.

We use a Spearman rank test to compare the efficiency scores computed with Model 1 and Model 2. We find a Spearman correlation coefficient greater than 0.95 which implies that the null hypothesis of independence of each measure of efficiency is rejected. In other words, banks with higher level of efficiency obtained with Model 1 are also those exhibiting a higher level of efficiency from Model 2. We therefore do not find different results when computing efficiency scores with Model 1, which mainly considers traditional banking activities, and Model 2 which considers both traditional and non-traditional banking activities.

The literature distinguishes efficient banks as those exhibiting constant returns to scale and inefficient banks as those exhibiting variable (increasing and decreasing) returns to scale. The results highlight differences in the number of observations with increasing and decreasing returns to scale when we use an input oriented model (Model 1) or an output oriented model (Model 2).

Table 1. Summary Statistics of Technical Efficiency Scores Computed with Equations 1 (DEA VRS Input-Oriented) and 2 (DEA VRS Output-Oriented Revenue Creation)

	Equation 1 (Model 1)			**Equation 2 (Model 2)**		
	TE1	**PTE1**	**SE1**	**TE2**	**PTE2**	**SE2**
	Full Sample (n=358)			*Full Sample (n=362)*		
Mean	0.3590	0.4546	0.7790	0.4468	0.5283	0.8446
Median	0.2420	0.3585	0.8850	0.4250	0.5015	0.8815
Minimum	0.0110	0.0410	0.0960	0.0620	0.0690	0.2760
Std. Dev.	0.3029	0.3278	0.2457	0.1878	0.1935	0.1580
	Constant returns (n=49)			*Constant returns (n=18)*		
Mean	0.7684	0.7685	0.9996	0.6255	0.6257	0.9998
Median	1.0000	1.0000	1.0000	0.5380	0.5385	1.0000
Minimum	0.0780	0.0790	0.9950	0.1490	0.1490	0.9990
Std. Dev.	0.3499	0.3498	0.0010	0.3077	0.3076	0.0003
	Increasing returns (n=220)			*Increasing returns (n=74)*		
Mean	0.2264	0.3294	0.7219	0.4718	0.5058	0.9394
Median	0.1630	0.2570	0.8340	0.4765	0.4975	0.9815
Minimum	0.0110	0.0410	0.0960	0.0990	0.1000	0.3540
Std. Dev.	0.1695	0.2566	0.2702	0.1821	0.1963	0.1117
	Decreasing returns (n=89)			*Decreasing returns (n=270)*		
Mean	0.4612	0.5911	0.7988	0.4280	0.5279	0.8083
Median	0.4230	0.5590	0.8580	0.4105	0.4995	0.8160
Minimum	0.0790	0.1300	0.2970	0.0620	0.0690	0.2760
Std. Dev.	0.2481	0.3041	0.1663	0.1723	0.1818	0.1572
			By country			
Hong Kong	0.3794	0.4797	0.7749	0.5474	0.6579	0.8405
Indonesia	0.2703	0.3909	0.7143	0.3829	0.4933	0.7744
Korea	0.5236	0.5709	0.9185	0.3374	0.4551	0.8610
Malaysia	0.3641	0.4389	0.8240	0.5050	0.5566	0.9079
Philippines	0.1545	0.2952	0.5880	0.4668	0.5067	0.7143
Thailand	0.4609	0.5940	0.8063	0.5272	0.5421	0.9589
			By year			
1999	0.3448	0.4484	0.7441	0.3595	0.4593	0.8037
2000	0.5757	0.7039	0.8257	0.3759	0.4768	0.8008
2001	0.3299	0.4150	0.7822	0.3966	0.4790	0.8264
2002	0.2962	0.4261	0.7252	0.4664	0.5425	0.8572
2003	0.3173	0.3746	0.8215	0.5168	0.5793	0.8904
2004	0.3152	0.3867	0.7813	0.6251	0.6802	0.9182

TE = technical efficiency; PTE = pure technical efficiency; SE = scale efficiency.

We find that 49 and 18 observations respectively exhibit constant returns to scale for Models 1 and 2; 220 observations exhibit increasing returns to scale for Model 1 whereas we only have 74 observations with increasing returns to scale when using Model 2; and 89 and 270 observations follow decreasing returns to scale respectively for Model 1 and for Model 2. The model specification is able to discriminate between efficient and inefficient banks as only 49 out of the 358 observations for Model 1 and only 18 out of 358 observations for Model 2, or 14% and 5% respectively are within the efficient frontier. Paradi, Vela and Yang (2005) note that when 25 to 50% of the sample lies on the frontier, it might become a problem for management to improve operations relative to other banks. Overall, the percentage of banks in the sample that are considered as technically inefficient is, on average, equal to 86 for Model 1 and 84 for Model 2. For the increasing returns group to reach the level of the efficient group, scale efficiency has to be improved by 28% if we consider Model 1(SE1) and 6% if we consider Model 2 (SE2). With the group exhibiting decreasing returns, the level of scale efficiency has to be improved by around 20%, whether we consider SE1 or SE2. The results also indicate that, during the post-crisis period, banks generally enjoy increasing returns when we consider Model 1 (with 220 out of 358 or 61.45%), whereas we find that banks mainly face decreasing returns to scale when considering Model 2 (with 270 out of 358 or 75.45%). Considering the pre-crisis period 1989-1996 for four ASEAN countries (Thailand, Malaysia, Indonesia and the Philippines), Karim (2001), using a parametric approach and considering only traditional activities, finds that on average ASEAN banks enjoy increasing returns to scale. Our results indicate therefore that Asian banks continue to benefit from increasing returns after the crisis period if we consider efficiency scores computed with Model 1, which includes only traditional banking activities. On the contrary, we find that Asian banks mainly face decreasing returns to scale in the post-crisis period when we include both traditional and non-traditional banking activities.

We further use the parametric and nonparametric tests of Banker (1993) to test if the efficient group is different from the inefficient group. The non-parametric Kolmogorov-Smirnov (KS) test is applied as we maintain no assumptions on the probability distribution of inefficiency in Equation 1. The KS test statistic is given by the maximum vertical distance between $F^{G1}(ln(\theta_j))$ and $F^{G2}(ln(\theta_j))$, the empirical distributions for groups G_1 and G_2, respectively. The KS test tries to determine if two datasets differ significantly, and the maximum difference between the cumulative distributions is given by the *D*-statistic. The *D-statistic*, by construction, takes values between 0 and 1 and a high value for this statistic is indicative of significant differences in inefficiency between two groups.

We find the *D-statistic* to be equal to 0.9472 and 0.9797 for TE1 (Model 1) and TE2 (Model 2) respectively, with a corresponding *p* value of 0.000, indicating highly significant difference between the groups (see Table 2). To check for robustness, we also test the efficient group against the two inefficient subgroups separately, and find the *D-statistic*s close to 1 with *p* values close to 0 for both Models 1 and 2, indicating highly significant differences in the efficiency scores.

Table 2. Comparison of Returns to Scale (TE1/TE2) Between Efficient and Inefficient Groups

	Cumulative Distribution Score	Null Hypothesis of No Difference
Model 1 (TE1)		
CRS vs IRS and DRS	*D*=0.9472***	Rejected
CRS vs IRS	*D*=0.9387***	Rejected
CRS vs DRS	*D*=0.9775***	Rejected
Model 2 (TE2)		
CRS vs IRS and DRS	*D*=0.9797***	Rejected
CRS vs IRS	*D*=0.9324***	Rejected
CRS vs DRS	*D*=0.9926***	Rejected

****indicates significance at p<0.01. CRS = constant returns to scale; IRS = increasing returns to scale; and DRS = decreasing returns to scale.*

The KS test is a robust test that only focuses on the relative distribution of the data. Hence the value of the *D-statistic* is not affected by scale changes. In Figure A1 in the Appendix, we can see that the KS percentile plot of the sets of efficiency scores is strikingly distinct. The efficient (CRS) scores plot appear as a vertical line on the far right side of the graph while the inefficiency scores (IRS and

DRS) turn up as upwardly diagonal, indicating that on the whole, the efficiency scores are not likely to be normally nor log-normally distributed.[7]

Table 3. Pair-wise Mean Test for Country Differences in Pure Technical Efficiency Scores

	Hong Kong	Indonesia	South Korea	Malaysia	Philippines	Thailand
Model 1						
Hong Kong	1.000					
Indonesia	0.0807	1.000				
South Korea	-0.0912	-0.179***	1.000			
Malaysia	0.0408	-0.048	0.131**	1.000		
Philippines	0.1845***	0.0957*	0.2752***	0.1437***	1.000	
Thailand	-0.1143	-0.2031***	-0.0195	-0.155**	-0.298***	1.000
Model 2						
Hong Kong	1.000					
Indonesia	0.1646***	1.000				
South Korea	0.2028***	0.0382	1.000			
Malaysia	0.1013***	-0.0633***	-0.1015***	1.000		
Philippines	0.1512***	-0.0134**	-0.0516**	0.0499**	1.000	
Thailand	0.1158*	-0.0488	-0.087	0.0145	-0.0354	1.000

****, **, * indicate significance at p<0.01, p<0.05, and p<0.10, respectively.*

We also check if pure technical efficiency and scale efficiency scores are different across countries by using the pair-wise mean test. When we consider pure technical efficiency, the results suggest that there exist differences in technical efficiency scores of banks across the six Asian countries under study (see Table 3). Indonesia and the Philippines reach the lowest average pure technical efficiency scores (Tables 1 and 3), both for Models 1 and 2. This result is consistent with Kwan's (2003) finding on Philippine banks exhibiting the highest per unit labor and per unit physical costs. South Korea and Thailand averages the highest overall pure technical efficiency score for Model 1, while Hong Kong averages the highest overall pure technical efficiency score for Model 2. We also observe significant differences between South Korea and Indonesia, and South Korea and the Philippines when we consider Model 1. For Model 2, we find strong significant differences between Indonesia and Thailand as well as between South Korea and Thailand (see Table 3). We obtain the same results when we consider scale efficiency (see Table 4).

We also check if pure technical and scale efficiency scores differ across ownership categories (Table 5). We use pair wise mean tests to compare technical efficiency scores between and among the five ownership categories[8]. When we consider technical efficiency scores computed with Model 1 (input minimization), we find that banks that are held by minority shareholders (widely-held) exhibit higher levels of efficiency relatively to other banks across the Asian region during the period 1999-2004. We also find that foreign-owned banks have higher levels of scale efficiency if we consider Model 2 (revenue creation).

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[7] Percentile plot is a better estimate of the distribution function and the use of probability scales allows us to see how normal the data are. Normally distributed and log-normal data will plot as a straight line on probability-scaled and probability-log scaled axes, respectively. The KS tests reported that the datasets on efficiency scores are unlikely to be normally or log normally (exponentially) distributed, hence the generalization that the datasets are non-parametric and distribution free. This justifies the choice of the D-statistic over the Student's *t* test in determining the differences between groups of banks.

[8] We are not able to use KS tests as previously because we do not have enough information for each category of ownership. The mean tests are available from the authors on request.

Table 4. Pair-wise Mean Test for Country Differences in Scale Efficiency Scores

	Hong Kong	Indonesia	South Korea	Malaysia	Philippines	Thailand
Model 1						
Hong Kong	1.000					
Indonesia	0.0606	1.000				
South Korea	-0.1436***	-0.2043***	1.000			
Malaysia	- 0.0491	-0.1097***	0.0945***	1.000		
Philippines	0.2169***	0.1263**	0.3305***	-0.236***	1.000	
Thailand	-0.0314	-0.091*	0.1122**	-0.017	-0.2183***	1.000
Model 2						
Hong Kong	1.000					
Indonesia	0.0661**	1.000				
South Korea	-0.0205***	-0.0866	1.000			
Malaysia	-0.0674**	-0.1335***	-0.0469***	1.000		
Philippines	-0.1262***	0.0601***	0.1467***	0.1936	1.000	
Thailand	-0.1184***	-0.1845***	0.0979***	-0.051**	-0.2446**	1.000

****, **, * indicate significance at p<0.01, p<0.05, and p<0.10, respectively.*

Table 5. Technical Efficiency and Ownership Structure

	Foreign-owned	State-owned	Private-owned	Institutional investor-owned	Widely-held
Model 1, PTE1					
Mean	0.378	0.443	0.501	0.423	0.460
Std	0.201	0.180	0 .254	0.214	0.221
Max	0.079	0 .232	0.079	0 .156	0.120
Min	0.776	0.748	1.000	0.460	0.773
Model 1, PTE2					
Mean	0.494	0.566	0.536	0.549	0 .537
Std	0.196	0.142	0.143	0.168	0.191
Max	0.162	0.302	0 .336	0.375	0.353
Min	1.000	0.757	1.000	0.919	0.959

PTE1=pure technical efficiency scores computed with Model 1; PTE2= pure technical efficiency scores computed with Model 2.

Table 6. Scale Efficiency and Ownership Structure

	Foreign-owned	State-owned	Private-owned	Institutional investor-owned	Widely-held
Model 1, SE1					
Mean	0.856	0.847	0.842	0.846	0.918
Std	0.073	0.061	0.069	0.064	0.068
Max	0.961	0.963	0.956	0.939	0.980
Min	0.714	0.758	0.697	0.748	0.776
Model 1, SE2					
Mean	0.906	0.866	0.824	0.799	0.891
Std	0.097	0.135	0.112	0.162	0.090
Max	0.991	0.998	0.998	0.984	0.993
Min	0.736	0.633	0.535	0.536	0.762

SE1= scale efficiency scores computed with Model 1; SE2= scale efficiency scores computed with Model 2.

To further investigate the relationship between bank efficiency and ownership, the pure technical and scale efficiency scores generated from Equations 1 and 2 are used as dependent variables in multiple regressions to determine if bank characteristics and country-specific environmental variables can explain differences in efficiency.

3 Determinants of Efficiency Scores

3.1 Regression analysis

To investigate the factors that might explain differences in efficiency levels, we focus on the ownership structure of banks along with a number of control variables such as bank size, leverage and asset risk. Total assets are used as a proxy for bank size. We also introduce the ratio of equity to total assets to capture the quality of bank management and risk preferences. We expect a negative coefficient as well-capitalized banks reflect both higher management quality and higher aversion to risk taking. These banks should be more cost efficient in producing banking outputs. We further include the ratio of loan loss provisions to net loans as a proxy of output quality. The literature provides mixed results on the expected sign of the coefficient of this variable. The coefficient can be negative if banks spend more resources on credit underwriting and loan monitoring, and consequently fewer problem loans at the expense of higher operating costs (Mester, 1996). The coefficient of this variable can be positive if banks have high ratio of loan loss provisions to net loans, indicating poor loan quality that calls for higher operating costs related to credit risk and loan loss management (Berger & DeYoung, 1997).

We also consider another measure of output quality, which is the standard deviation of the return on assets (ROA). This broader measure of asset risk might be more appropriate for Model 1 where we consider as outputs not only net loans but also total securities and other earning assets. This measure of risk should also be applicable for Model 2, which accounts for traditional and non-traditional banking activities.

Regarding ownership structure variables, we build five different dummy variables referring to the nature of ownership. We consider that there is a majority ownership when an owner holds at least 33% of the stockholders' equity. As the owners are classified in five categories, we create the following five dummy variables which takes the value of one when ownership is at least equal to 33% of the equity and 0 otherwise: state-owned, foreign-owned, private-owned, institutional investor-owned and widely-held. The different types of bank ownership refer to different forms of governance as discussed in Berger et al. (2005). Studies of U.S. corporations typically use the governance term to refer to the methods shareholders use to reduce managerial agency cost, such as board composition, voting rules, or stakes by managers. Ownership is assumed to be related to a bank's performance because the incentives for managers to efficiently allocate resources might differ under different ownership types or arrangements.

We then estimate the following cross-section equations to determine which factors are efficiency drivers:

$$Eff_i = \alpha \; BankChar_i + \; \beta \; Ownership_i + \eta_i$$

where the dependent variable *Eff* is the average technical or scale efficiency score computed either with Model 1 or with Model 2 for bank *i*. *BankChar* is the vector of bank characteristics and *Ownership* is the vector of ownership variables. We remove, however, the dummy variable representing private banks to avoid singularity. Private banks are therefore the reference banks upon which we base and compare the resulting coefficient estimates of our vector of ownership variables. α and β are the coefficients of the estimates and η is the disturbance term.

Because the efficiency scores generated by DEA models are dependent on each other, we use bootstrap estimators to calculate standard errors of our estimates (Xue & Harker, 1999; Casu & Molyneux, 2003). The DEA efficiency score is not an absolute efficiency index, but a relative efficiency score. The assumption of independence within the sample is therefore violated and conventional OLS is invalid. The results throughout this paper are obtained from 10,000 bootstrap iterations. The estimation results are displayed in Table 7.

Regarding efficiency as measured in Model 1, we find that the log of total assets, as a proxy for size, does not affect pure technical efficiency. We also find a significant negative sign for the equity to total assets variable both for pure technical and scale efficiencies. The coefficient associated with the ratio of loan loss provisions to net loans is not significant and therefore loan quality does not seem to alter efficiency. However, the coefficient of the broader measure of asset risk (standard deviation of ROA) is positive and significant when we consider scale efficiency, though only at the 10% level. With regards to the ownership structure variables, we find "widely-held" banks more technical and scale efficient than private banks.

In the case of Model 2, bank size (log of total assets) significantly and positively influences pure technical efficiency. Large banks are on average more efficient than smaller banks. In Model 2, inputs and output measures are revenue-focused. It is therefore expected that Model 2 might yield different results compared to Model 1 because efficiency estimates are sensitive to input and output specification (Berger, Hunter & Timme, 1993). In terms of scale efficiency, we find the coefficient associated with the equity to total assets variable not significant. As such, there appears to be no relationship between the degree of leverage and efficiency. However, the results indicate that the relationship between the degree of leverage and scale efficiency is positive. We also find "foreign-owned" banks to be more scale efficient compared to private banks when revenue creation objective is considered. The results from Model 2 also confirm that banks which are held by minority private shareholders ("widely-held") have higher scale efficiency scores.

3.2 Robustness checks and discussion of results

We check the robustness of our results by considering environmental variables as determinants of efficiency scores. The objective of incorporating such variables is to associate variation in bank performance with variation in the exogenous variables characterizing the environment in which bank production and intermediation occurs. The exogenous variables influence performance not by influencing efficiency, with which they are assumed to be uncorrelated, but by influencing the structure of the technical and cost efficient frontier. Dietsch and Lozano-Vivas (2000) underline three categories of environmental variables that influence cost efficiency as a guide for cross-country studies: i) those that describe the main macroeconomic conditions which determine the banking product demand characteristics; ii) the variables that describe the structure and regulation of the banking industry; and, iii) those that characterize the accessibility of banking services.

In this study, we account for macroeconomic conditions by including the real GDP growth rate (GDP) following Pastor (1999)[9], which falls under the first category as prescribed by Dietsch and Lozano-Vivas (2000). We also introduce the difference between the loans and savings deposit interest rates (SPREAD) as a proxy for the structure and competition in the different national banking systems. A smaller gap between the loans and savings rates suggests a more competitive environment. Finally, we introduce the coefficient of variation of the country's exchange rate with respect to the US dollar (FOREX), which should capture the volatility of the local currency.

We find that environmental variables, on the whole, influence efficiency scores (see Table A3 in Appendix). The variable GDP is significant with a positive influence on scale efficiency, when considering Model 1 (TE1) with the ratio of loan loss provisions to net loans taken as a proxy of output quality. However, the relationship with pure technical efficiency is negative. In addition, we find a negative relationship between the variable FOREX and the two efficiency measures. Our results, therefore, highlight that the factors that influence efficiency depend on the economic environment. In examining the effects of ownership structure, the results remain the same. Consistent with the previous results, we find "foreign-owned" banks to be more scale efficient than private banks but only in terms of revenue creation efficiency (SE2). Our results also show that "widely-held" banks are more scale and technically efficient.

9 Pastor (1999) also introduces the use of unemployment rate and inflation rate as environmental variables. We do not use these two variables in our regressions as they are strongly correlated with the real GDP growth rate and the interest rate spread.

Table 7: Determinants of Efficiency Scores (Bootstrap Estimators)

	Pure technical efficiency				Scale efficiency			
	PTE1		PTE2		SE1		SE2	
Intercept	0.512***	0.292	0.014	0.179	0.859***	0.849***	0.810***	0.829***
	(1.786)	(0.839)	(0.054)	(0.642)	(34.236)	(34.798)	(22.927)	(17.584)
Ln Total assets,	0.004	0.017	0.031**	0.019	0.0006*	0.0006*	-0.0005*	-0.0005*
average	(0.247)	(0.909)	(2.006)	(1.184)	(1.672)	(1.689)	(-1.990)	(-1.807)
Total equity/total assets,	-0.013**	-0.009	0.859**	0.779*	-0.003*	-0.002	0.248	0.293
average	(-2.463)	(-1.342)	(2.256)	(1.765)	(-1.791)	(-1.261)	(1.293)	(1.297)
Loan loss provisions/net	-0.002	-	-0.010	-	0.003	-	0.006	-
loans,	(-0.210)		(-1.082)		(0.563)		(1.174)	
average								
Standard deviation of ROA	-	0.002	-	0.143	-	0.012*	-	-0.003
		(0.077)		(0.143)		(1.723)		(-0.536)
Foreign-owned	0.024	0.005	-0.035	-0.020	0.003	-0.005	0.071**	0.092***
	(0.154)	(0.056)	(-0.706)	(0.447)	(0.154)	(0.018)	(2.271)	(2.869)
Institutional investor owned	-0.046	-0.038	0.007	0.005	0.006	-0.003	-0.042	-0.052
	(-0.839)	(-0.621)	(0.101)	(0.068)	(0.227)	(-0.113)	(-0.795)	(-1.005)
State-owned	-0.072	-0.099	0.043	0.039	-0.011	-0.011	0.033	0.034
	(-0.935)	(-1.204)	(0.903)	(0.805)	(-0.522)	(-0.491)	(0.727)	(0.742)
Widely-held	0.187***	0.159*	-0.029	0.006	0.077***	0.068**	0.088**	0.079*
	(2.736)	(1.862)	(-0.484)	(0.083)	(2.815)	(2.310)	(2.507)	(1.885)
Number of observations	76	71	71	63	78	71	71	63
R^2	0.1815	0.1706	0.2421	0.1398	0.2440	0.2956	0.2718	0.2912

*t-statistic in parentheses; ***, **, * indicate significance at p<0.01, p<0.05, and p<0.10, respectively. PTE1 and PTE2, and SE1 and SE2 are respectively pure technical and scale efficiencies from Model 1 (input minimization) and Model 2 (revenue model). Foreign-owned, Institutional investor-owned, State-owned, and Widely-held are dummy variables.*

The results of our econometric investigation show that the differences in efficiency scores are explained by both general economic environment and bank specific characteristics such as ownership structure. We find that the relationship between efficiency and size is positive and significant when we consider an input minimization objective (Model 1) and negative when we consider revenue creation (Model 2). We do not find a strong relationship between bank leverage and efficiency levels, and loan quality does not appear to determine efficiency levels. To a lesser extent, risk taking is a significant and positive driver of technical efficiency when an input minimization objective is considered.

Regarding the ownership structure, we find that banks that are held by minority shareholders exhibit higher levels of efficiency over the post-crisis period. This result is not consistent with the findings of Laeven (1999) which show that widely-owned banks experienced a decrease in efficiency relative to other banks across the Asian region during the period 1992-1996. Based on the same ownership definition as proposed by Laeven (1999), our results highlight that for the post-crisis period, Asian banks that do not exhibit a concentrated ownership have higher efficiency levels. Therefore, our findings do not support the hypothesis of a positive impact of concentration on efficiency. We also find that foreign-owned banks are more efficient than other domestic banks when we consider revenue creation. This is consistent with Laeven (1999) who highlights that foreign-banks showed an increase in efficiency relative to other banks in the pre-crisis period 1992-1996.

4 Conclusion

The aim of this paper is to assess the implications of the restructuring process imposed on banking industries in Southeast and East Asia after the 1997 financial crisis. Within a regional approach involving six countries (Hong Kong, Indonesia, South Korea, Malaysia, Philippines and Thailand), we find that Asian banks generally benefit from increasing returns after the crisis period. However, we observe persistent differences in efficiencies across countries. Efficiency scores are relatively high for South Korea and relatively low for Thailand and the Philippines. The results of our econometric investigation show that such differences can be explained by bank specific characteristics. Efficiency is driven by bank size and to a lesser extent by risk taking. Among our main findings, which are robust, are that banks owned by minority private shareholders and by foreign investors appear to be more efficient than private banks during the post-crisis period. Therefore, unlike some studies that report a positive effect of ownership concentration on efficiency in the region during the pre-crisis period (Laeven, 1999), our results suggest that corporate governance reforms might be beneficial to minority shareholders. Our second result regarding the role of foreign investors is consistent with previous studies. However, the advantage of foreign banks is attributed to scale efficiency. Hence, our findings imply that the entry and growing involvement of foreign investors is still beneficial for the efficiency of the banking industry in the region.

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Appendices

Figure A1. KS-Test Comparison Percentile Plot (Model 1)

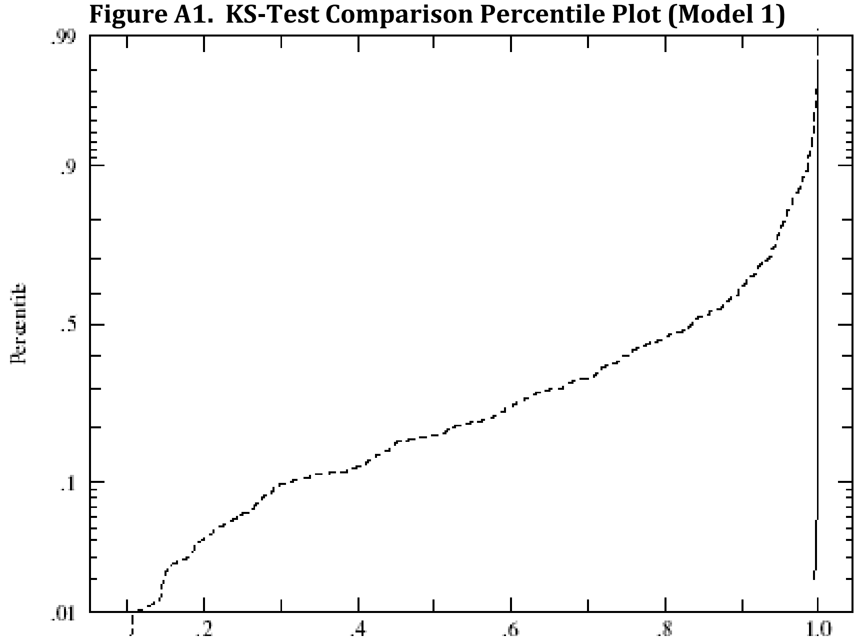

Table A1. Distribution of Sample
Number of Banks by Category of Shareholder and by Country

	Foreign_owned	*Institution*	*State_owne*	*Widely_owned*	*Private_owned*	*Total*
Hong Kong	5	2	0	1	9	17
Indonesia	0	1	5	0	6	12
South	2	1	1	2	7	13
Malaysia	8	1	1	1	9	20
Philippines	1	4	1	2	4	12
Thailand	1	2	1	2	0	6
Total	17	11	9	8	35	80

Number of observations by country and by year

Year	*Hong Kong*	*Indonesi*	*South Korea*	*Malaysi*	*Philippine*	*Thailand*	*Total*
1999	15	0	10	18	12	3	58
2000	11	0	13	15	11	4	54
2001	8	12	12	16	11	6	65
2002	8	12	12	15	10	6	63
2003	8	12	12	13	9	6	60
2004	8	12	12	13	7	6	58
Total	58	48	71	90	60	31	358

Table A2. Descriptive Statistics for the Panel of 80 Asian Commercial Banks, on Average Over the Period 1999-2004

	ROA	ROE	TA	LOAN	DEPOSIT	SECURITY	EQUITY	TCR	EXPENSES	NPL	Int_TR	OOE	NII	NNII
Full Sample (n=358)														
Mean	0.72	6.48	18,073,213	53.12	75.62	19.45	8.83	16.53	0.94	10.76	4.57	0.88	68.73	29.22
Standard Deviation	1.76	46.74	38,068,828	0.14	0.09	0.13	5.10	9.17	0.44	9.11	2.54	0.75	28.31	20.61
Hong Kong (n=58)														
Mean	0.93	10.57	34,098,731	50.98	74.11	14.66	10.94	22.25	0.75	5.83	3.37	0.59	73.38	26.61
Standard Deviation	0.74	8.22	75,197,145	0.12	0.12	0.12	3.78	14.43	0.27	9.77	1.92	0.18	16.34	16.33
Indonesia (n=48)														
Mean	1.56	2.67	7,087,021	39.92	79.60	33.84	8.84	20.03	1.24	6.16	8.22	0.29	77.87	16.17
Standard Deviation	1.27	94.27	7,795,652	0.14	0.06	0.16	4.24	8.81	0.73	5.72	2.73	0.33	46.40	32.15
South Korea (n=71)														
Mean	0.07	1.13	42,096,997	59.80	74.72	22.25	4.13	10.16	0.77	5.08	4.79	0.64	66.07	33.92
Standard Deviation	1.55	42.95	36,816,438	0.07	0.07	0.08	2.31	6.55	0.23	7.77	1.50	0.40	14.28	14.27
Malaysia (n=90)														
Mean	0.77	14.39	8,010,051	57.29	75.94	19.62	8.31	15.40	0.75	13.49	3.73	0.46	66.49	30.75
Standard Deviation	1.65	35.69	9,699,452	0.15	0.07	0.09	4.86	7.83	0.17	7.67	2.42	0.17	27.26	11.21
Philippines (n=60)														
Mean	0.74	3.52	3,056,757	51.08	70.53	8.65	13.70	17.47	1.33	16.06	4.71	2.13	59.93	38.83
Standard Deviation	1.41	16.65	2,940,187	0.09	0.09	0.09	4.66	6.31	0.26	8.36	1.54	0.50	17.12	14.60
Thailand (n=31)														
Mean	0.30	0.21	8,358,389	55.11	83.78	20.09	7.70	14.68	1.04	12.12	2.84	1.69	65.01	34.98
Standard Deviation	3.67	54.31	6,345,847	0.18	0.07	0.16	4.05	3.23	0.60	9.08	1.25	0.61	13.41	13.40

Variable definitions (all ratios are expressed in percentages): ROA = return on average assets; ROE = return on average equity; TA : total assets in millions of US dollars; LOANS = net loans/total assets; DEPOSIT = deposits/total assets; SECURITY= securities /total assets; EQUITY = equity/total assets; TCR = total capital ratio; EXPENSES = personnel expenses/total assets; NPL = nonperforming loans/gross loans; Int_TR = interest expenses/total resources; OOE = operating expenses/total assets; NII = net interest income/net operating income; NNII = net non-interest income/ net operating income.

Table A3. Regression of Efficiency Scores with Ownership Structure and Environmental Variables (Bootstrap estimators)

	Pure technical efficiency				Scale efficiency			
	PTE1		PTE2		SE1		SE2	
Intercept	0.423	0.712	0.150	0.337	0.662***	0.715***	0.601***	0.763***
	(0.964)	(1.538)	(0.429)	(0.874)	(6.373)	(6.113)	(3.204)	(3.458)
Ln Total assets, average	-0.002	0.009	0.048***	0.029*	0.0006*	0.0001*	-0.0005	-0.0002
	(-0.117)	(0.389)	(2.978)	(1.826)	(1.917)	(1.702)	(-1.501)	(-1.492)
Total equity/total assets, average	-0.010*	-0.009	0.846**	0.716	-0.002	-0.002	0.336	0.305
	(-1.669)	(-1.282)	(2.122)	(1.393)	(-0.960)	(-0.838)	(1.593)	(1.150)
Loan loss provisions/net loans, average	-0.002	-	-0.011	-	-0.000	-	0.006	-
	(-0.021)		(-1.232)		(-0.009)		(1.193)	
Standard deviation of ROA	-	0.004	-	-0.001	-	0.010	-	-0.004
		(0.200)		(-0.072)		(1.471)		(-0.554)
Foreign-owned	-0.008	-0.028	-0.008	0.003	-0.00	-0.005	0.064*	0.093***
	(-0.089)	(-0.310)	(-0.163)	(0.063)	(-0.211)	(-0.263)	(1.905)	(2.833)
Institutional investor owned	-0.030	-0.032	0.047	0.046	-0.007	-0.010	-0.499	-0.044
	(-0.525)	(-0.524)	(0.704)	(0.659)	(-0.227)	(-0.369)	(-0.775)	(-0.760)
State-owned	-0.039	-0.047	0.062	0.058	-0.027	-0.020	0.038	0.038
	(-0.496)	(-0.584)	(1.478)	(1.247)	(-1.176)	(-0.842)	(0.780)	(0.815)
Widely-held	0.190***	0.149*	0.013	0.031	0.063***	0.060**	0.085*	0.082*
	(2.773)	(1.696)	(0.246)	(0.546)	(2.230)	(1.961)	(1.914)	(1.847)
GDP	0.034	-0.036	-0.080*	-0.059	0.031**	0.020	0.033	0.008
	(0.632)	(-0.646)	(-1.976)	(-1.467)	(1.977)	(1.128)	(1.073)	(0.244)
FOREX	-0.446	-1.288**	-1.127**	-1.251**	0.509	0.302	0.156	0.005
	(-0.706)	(-2.226)	(-2.218)	(-2.369)	(2.463)	(1.316)	(0.411)	(0.013)
SPREAD	0.001	-0.012	0.005	0.004	0.004	0.003	0.006	0.004
	(0.097)	(-0.927)	(0.616)	(0.462)	(1.081)	(0.848)	(0.872)	(0.534)
Number of observations	76	71	71	63	76	71	63	63
R^2	0.2007	0.2256	0.4184	0.3438	0.3169	0.3248	0.2842	0.3025

*t-statistic in parentheses; ***, **, * indicate significance at p<0.01, p<0.05, and p<0.10, respectively. PTE1 and PTE2, and SE1 and SE2 are respectively pure technical and scale efficiencies from Model 1 (input minimization) and Model 2 (revenue model). Foreign-owned, Institutional investor-owned, State-owned, and Widely-held are dummy variables. GDP= real GDP growth rate; FOREX= coefficient of variation of the country's exchange rate measured in US dollars; SPREAD = difference between loan and saving deposit interest rate.*